CLAIMS

What is claimed is:

1. A method of making a composite laminate material comprising:
interleaving
a plurality of first foils made from one or more first metals and metal alloys, with
a plurality of second foils made from one or more second metals and metal alloys suitable to compound with the one or more first metal and metal alloys to produce a hard intermetallic compound; and
reacting under heat and pressure in the presence of atmospheric gases the plurality of first foils with the plurality of second foils so as to substantially completely react the one or more second metals and metal alloys with the one or more first metal and metal alloys, forming where each second metal foil had been a region of hard intermetallic compound;
wherein a composite laminate material having (i) layers of one or more first metals and metal alloys, interspersed with (ii) regions of an hard intermetallic compound, is made.

2. A method of making a composite laminate material comprising:
interleaving
a plurality of first foils made from one or more first metals or metal alloys from the group consisting of titanium, nickel, vanadium, iron and alloys and combinations of titanium, nickel, vanadium and iron, with
a plurality of second foils made from one or more second metals and metal alloys from the group consisting of aluminum and alloys of aluminum; and
reacting under heat and pressure in the presence of atmospheric gases the plurality of first foils with the plurality of second foils so as to substantially completely react the one or more second metals and metal alloys with the one or more first

at least one second metals and metal alloys from which the second foils are made is exceeded in the process.

4. The method according to claim 1 or claim 2 wherein the interleaving is of a pluralities of first and second foils more numerous than ten.

5. The method according to claim 1 or claim 2 wherein the interspersing is of pluralities of first and second foils having thicknesses in the range of .1 mm to 1 mm.

6. The method according to claim 1 or claim 2 wherein the interspersing is of pluralities of first and second foils having thicknesses less than .2 mm.

7. The method according to claim 1 or claim 2 wherein the maximum temperature of the reacting is in the range from 600-800°C.

8. The method according to claim 1 or claim 2 wherein the reacting under heat and pressure comprises:
pressuring in a mechanical press.

9. The method according to claim 1 or claim 2 wherein the reacting under heat and pressure comprises:
pressuring in a load frame.

10. The method according to claim 1 or claim 2 wherein the reacting under heat and pressure is under a maximum pressure in the range from 1-10 megapascals.

11. The method according to claim 1 wherein the interspersing is of a plurality of first foils made of one or more metals and metal alloys from the group

consisting of titanium, nickel, vanadium, iron and alloys and combinations of titanium, nickel, vanadium and iron.

12. The method according to claim 1

wherein the interspersing is of a plurality of second foils made of one or more metals and metal alloys from the group consisting of aluminum and alloys of aluminum.

13. The method according to claim 1 or claim 2

wherein the interspersing is of a plurality of first foils made from one or more first metals and metal alloys having a plane strain fracture toughness, in the state of the first metals and metal alloys that is assumed upon completion of the method, of greater than 40 $MPa\sqrt{m}$, with a plurality of second metal foils made from one or more second metals and metal alloys suitable to compound with the first metal and metal alloys to produce an intermetallic compound having a Vickers microhardness of greater than 400 kg/mm^2.

14. The composite laminate material produced by the process of claim 1 or claim 2, characterized for having (i) layers of one or more first metals and metal alloys, interspersed with (ii) regions of an intermetallic compound consisting of the one or more first metals and metal alloys reacted with the one or more second metals and metal alloys.

15. A composite laminate material consisting of

a plurality of metal layers of one or more tough first metals or metal alloys; interleaved with

a plurality of regions, coextensive with the metal layers, of hard intermetallic material consisting of the one or more first metals and metal alloys compounded with one or more second metals or metal alloys;

wherein the tough metal layers are separated by the hard

intermetallic regions; and

wherein no second metals or metal alloys exist in native form, all being within the hard intermetallic material.

16. The composite laminate material according to claim 15

wherein the one or more tough first metals and metal alloys are drawn from the group consisting of titanium, nickel, vanadium and iron, and combinations of titanium, nickel, vanadium, and iron.

17. The material according to claim 15

wherein the one or more second metals or metal alloys are drawn from the group consisting of aluminum and alloys of aluminum.

18. The material according to claim 15 in a non-planar contour.

19. The material according to claim 18 in corrugated form.

20. A composite laminate material consisting of

a plurality of metal layers consisting of titanium, nickel, vanadium, and iron and alloys and combinations of titanium, nickel, vanadium, and iron; interleaved with

a plurality of intermetallic regions, coextensive with the metal layers, consisting of

said titanium, nickel, vanadium, and iron and alloys and combinations of titanium, nickel, vanadium, and iron; compounded with

aluminum and alloys of aluminum;

wherein intermetallic regions exist as boundaries between the metal layers;

wherein no aluminum nor alloys of aluminum exist in native form, all being within the hard intermetallic material.

21. The composite laminate material according to claim 15 or claim 20 having a density between 3 and 4.5 grams per cubic centimeter.

22. The composite laminate material according to claim 15 or claim 20 having a density less that 6 grams per cubic centimeter.

23. The composite laminate material according to claim 15 or claim 20 having residual internal stresses between the metal layers and the intermetallic regions.

24. The composite laminate material according to claim 15 or claim 20 adapted for use as armor.

25. The composite laminate material according to claim 15 or claim 20

wherein the metal layers are in a three-dimensional, non-planar, contour;

wherein the intermetallic regions are in a three-dimensional, non-planar, contour congruent with the contour of the metal layers;

whereby the composite laminate material is in a three-dimensional, non-planar, contour.

26. The composite laminate material according to claim 15 or claim 20

wherein the metal layers are in a corrugated contour;

wherein the intermetallic regions are in a corrugated contour congruent with the contour of the metal layers;

whereby the composite laminate material is in a corrugated contour.

27. The composite laminate material according to claim 15 or claim 20

wherein the metal layers are greater than 10 in number and larger than 100 cm^2 in area.

28. The composite laminate material according to claim 15 or claim 20

wherein the metal layers have a toughness, in the state of the metals and metal alloys that is assumed upon completion of the method, of greater than 40 MPa$\sqrt{m}$.

29. The composite laminate material according to claim 15 or claim 20

wherein the regions of intermetallic material have a Vickers microhardness of greater than 400 kg/mm^2.

30. Armor comprising:

at least 10 metal layers, at least 100 cm^2 in area, of at least one tough first metal or metal alloy; separated by and interleaved with

at least 9 hard intermetallic regions, coextensive with the metal layers and thus at least 100 cm^2 in area, of (i) the at least one tough first metal or metal alloy compounded with (ii) at least one second metal or metal alloy;

in a laminate composite having the tough metal layers separated by the hard intermetallic regions;

wherein no second metals or metal alloys exist in native form, all being within the hard intermetallic material.

31. The armor according to claim 30

wherein the at least one tough first metal or metal alloy is drawn from the group consisting of titanium, nickel, vanadium and iron, and combinations of titanium, nickel, vanadium, and iron.

32. The armor according to claim 30

wherein the at least one second metal or metal alloy is drawn from the group consisting of aluminum and alloys of aluminum.

33. Armor comprising:

at least 10 metal layers, at least 100 cm^2 in area, consisting of titanium, nickel, vanadium, and iron and alloys and combinations

of titanium, nickel, vanadium, and iron; interleaved with

at least nine intermetallic regions, coextensive with the metal layers and thus at least 100 cm^2 in area, consisting of

said titanium, nickel, vanadium, and iron and alloys and combinations of titanium, nickel, vanadium, and iron; compounded with

aluminum and alloys of aluminum;

wherein intermetallic regions exist as boundaries between the metal layers;

wherein no aluminum nor alloys of aluminum exist in native form, all being within the hard intermetallic material.

34. Armor according to claim 30 or claim 33 having a density between 3 and 4.5 grams per cubic centimeter.

35. Armor according to claim 30 or claim 33 having a density less that 6 grams per cubic centimeter.

36. Armor according to claim 30 or claim 33 having residual internal stresses between the metal layers and the intermetallic regions.

37. Armor according to claim 30 or claim 33

wherein the metal layers are in a three-dimensional, non-planar, contour;

wherein the intermetallic regions are in a three-dimensional, non-planar, contour congruent with the contour of the metal layers;

whereby the armor is in a three-dimensional, non-planar, contour.

38. Armor according to claim 30 or claim 33

wherein the metal layers are in a corrugated contour; and

wherein the intermetallic regions are in a corrugated contour congruent with the contour of the metal layers;

whereby the composite laminate material is in a corrugated contour.

39. Armor according to claim 30 or claim 33 wherein the metal layers have a toughness greater than 40 MPa$\sqrt{m}$.

40. Armor according to claim 30 or claim 33 wherein the regions of intermetallic material have a Vickers microhardness of greater than 400 kg/mm^2.

41. Armor according to claim 30 or claim 33 wherein the metal layers are of differing thickness.

42. Armor according to claim 30 or claim 33 wherein the intermetallic regions are of differing thickness.

43. Armor according to claim 30 or claim 33 having such residual internal stresses between the metal layers and intermetallic regions as do serve to more substantially deflect a penetrating projectile from off its axis of impact than would be the case for the same penetrating projectile without the residual internal stresses.